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THE BRYOLOGIST

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MOSSES AS ROCK BUILDERS[1]

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The history of the travertine now to be found in the Arbuckle Mountains of the south-central part of Oklahoma begins with the removal of the Cretaceous strata from the underlying Paleozoic rocks during the Pleistocene age; a cycle of erosion that reduced the ancient mountains to a plateau radially dissected by short streams with small flood plains, rapids, and waterfalls. Some of these waterfalls were altered by the accumulations of the recent deposits of soft limestone—travertine—to such an extent that the falls attained a maximum height of 60 to 100 feet, and a width of 100 yards to nearly a half mile. The physiographic factors that have influenced the growth of these recent deposits have been aided in their work, to a considerable extent, by the presence of certain water plants, especially the tufted growths of the mosses *Didymodon tophaceus* (Brid.) Jur. and *Philonotis calcarea* Sch.

The dense tufts of *Didymodon* are more commonly distributed along the moist ledges extending across the shallow streams. From an examination of the various travertine ledges, plants of *Didymodon* evidently had a greater share in the building of this kind of rock than the plants of *Philonotis*. A third species of water moss, *Octodiceras Julianum* Brid., was also found in small quantities in three different locations. The long branched moss stems fixed the tangled masses of algae, *Oedogonium* and *Vaucheria*, to the rock surfaces of the rapids or cascades. These little mats of plants bend with the undulating surface of the running water and apparently stretch like rubber. The water evaporates from the more exposed plant surfaces; carbon dioxide gas diffuses into the air; the minerals held in solution concentrates in the plant mass; while calcium carbonate slowly crystallizes about the filaments in a manner very much like the formation of crystals about strings that are suspended in a saturated solution of cane sugar. The young plants at the surface of the water continue to grow, but the incased filaments gradually decay, leaving behind small calcareous tubules arranged like a mass of coarse fiber.

The incrustations about plants of the water moss *Didymodon* are more evident than those formed about algae or the mosses *Octodiceras* and *Philonotis*. The dense moss tufts, projecting one to four inches above the surface of the water at the margin of waterfalls, are always saturated like a sponge. As the water evaporates from the leaves and stems, most of the free carbon dioxide escapes

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[1] Contribution from the Department of Botany, University of Pittsburgh.

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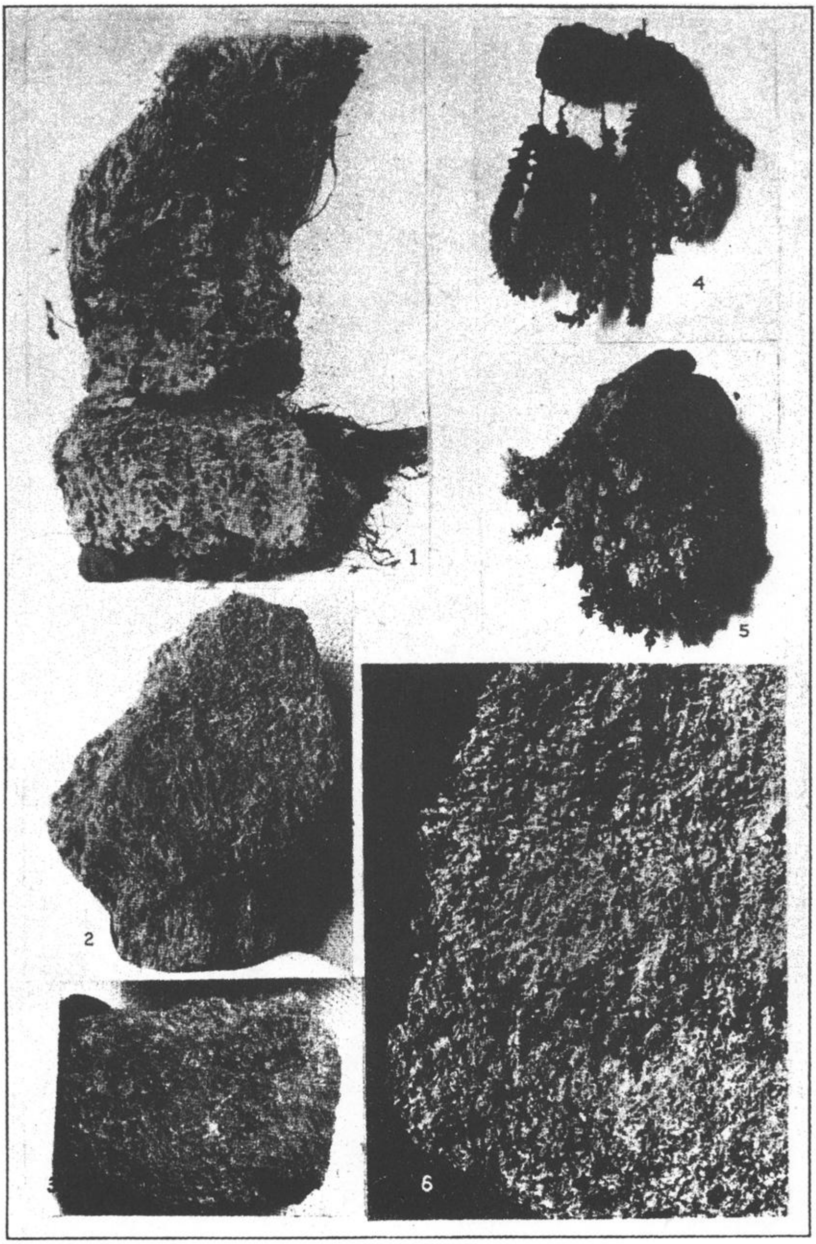

Didymodon tophaceus (Brid.) Jur., forming travertine (*See* Explanation, p. 27) into the air and only a comparatively small amount of free carbon dioxide or the carbon dioxide derived from the bicarbonates in solution is used by the mosses during the process of photosynthesis. The change of equilibrium, induced by the loss of carbon dioxide from the mineral water, is followed by a separation of calcium carbonate in such a manner as to place a white crystalline covering on the outer surfaces of the plants. The transition from the moss plant to incrustation, Plate XV, fig. 1, and finally to compact limestone, Plate XV, fig. 2, is a very slow development. The moss leaves and stems with their initial covering of crystals, Plate XV, fig. 1, serve as centers for the continued formation of travertine. In the interstices of this coral-like mass, the gradual accumulation of calcite gives rise to a hard but cavernous limestone. The fractured, longitudinal surfaces of the hardened travertine often show impressions or casts which indicate the position of the original moss leaves. Cross sections of the same travertine, Plate XV, fig. 3, reveal small and regular canals which have changed but little since the decay of the incrusted moss stems.

By the action of the same physical and chemical agents described above, another type of travertine is produced if the moss *Didymodon* happens to grow suspended from the projecting ledges of waterfalls. Under these conditions the incrustations follow the development of the moss to within a few m.m. of the growing tips, transforming the leaves into rounded calcareous beads, Plate XV, fig. 4, which are finally cemented together into a soft mass of travertine. Fractured longitudinal surfaces of the hardened travertine, as shown in fig. 6, presents the arrangement of calcareous beads, which in all essentials are like the rounded masses of calcium carbonate as represented in fig. 4. Thus the type of travertine formed by the moss *Didymodon* depends largely on the original position of the growing plants. If the moss appears in erect tufts, Plate XVI, fig. 1, on the exposed surfaces of rapids, the travertine formed is like that shown in Plate XV, fig. 2; but if the plants grow suspended from overhanging ledges of waterfalls, Plate XVI, fig. 2, the travertine is like that represented in Plate XV, fig. 6.

In the newly formed cavernous deposits, water mosses, and filamentous and unicellular algae are usually present. The most active deposition, 3 to 5 inches during a single summer, takes place in the presence of *Vaucheria*. But the development of travertine about moss plants will not exceed one inch per year under the most favorable circumstances; for as soon as the interior of certain tufts have hardened, the water currents will be diverted through other less resistant channels. The various streamlets shift from place to place on account of the unequal development and incrusting of the mosses. The growth of each separate moss tuft is intermittent.

The mosses, however, are not the primary factors in the building of the travertine falls. If boulders collect in the channels so as to form a series of rapids, then the water mosses growing in the shallow currents will aid in the cementing of the boulders into a conglomerate dam. In addition, the travertine deposits have modified the appearance of practically all of the natural falls of the Arbuckle Mountains. On Honey Creek at the present site of Turner

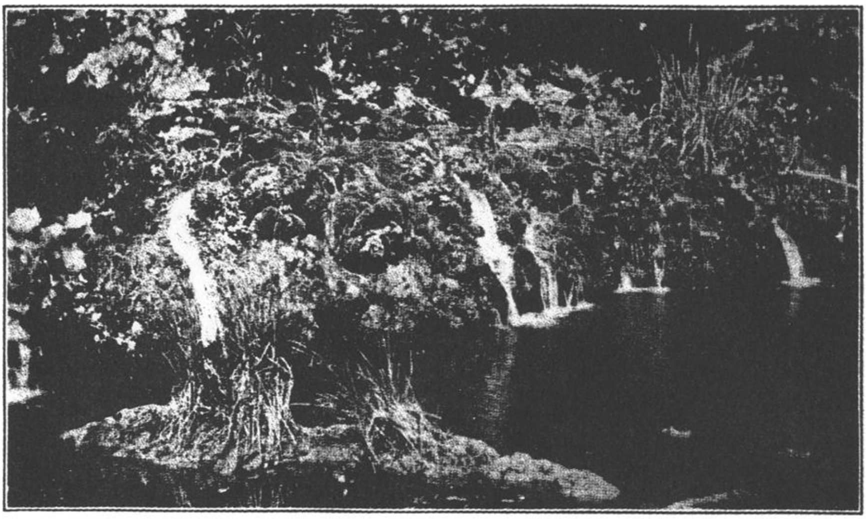

FIG. 1.—A travertine falls on Falls Creek, Oklahoma; tufts of *Didymodon* and *Philonotis* covering the greater part of the falls.

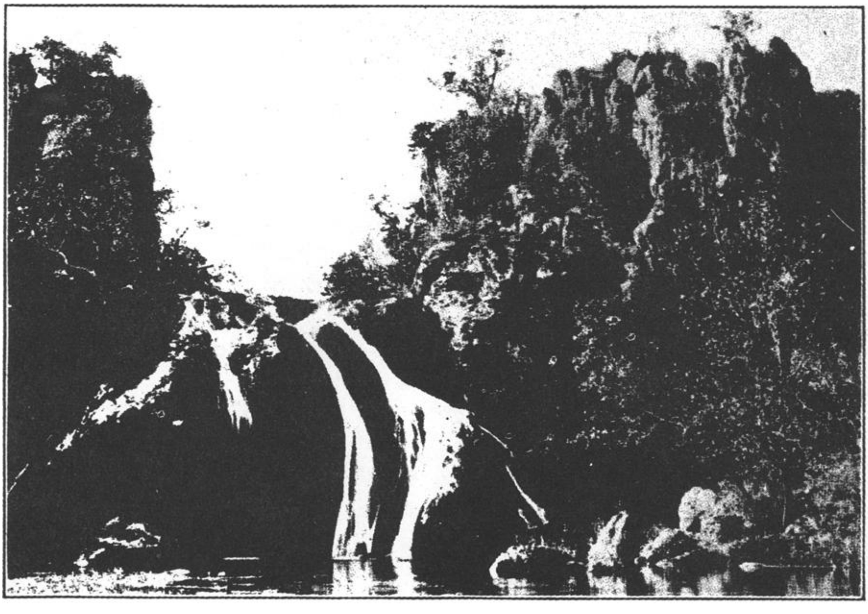

FIG. 2.—Turner Falls, on Honey Creek near Davis, Oklahoma; a travertine falls developing on plants of algae and mosses. (After Emig: Travertine Deposits of Oklahoma. Okla. Geol. Surv. Bull. **29**: 21. 1917).

Falls, Plate XVI, fig. 2, the calcareous deposits are 60 feet thick immediately above the natural fall, but as they extend upstream for a distance of 150 yards, they gradually diminish to only a few feet in thickness. At one time travertine covered completely the present Turner Falls, which are about one-eighth their former size. During the last extensive erosion cycle, the unwashed formation on either side of the main channel was unaltered, but as the soft portions of the rocks crumbled away, the channel became deeper, the fissures in the travertine opened and were extended into a deep gorge. In spite of successive erosions, the travertine continues to grow by the aid of algae and mosses. The mosses act only indirectly in the precipitation of calcium carbonate, principally by supplying a larger absorptive and adsorptive surface for the evaporation of the calcareous water.

EXPLANATION OF PLATE XV

Didymodon tophaceus (Brid.) Jur. × ⅓

1. Recent travertine showing the mode of travertine formation about moss plants that grow in erect tufts.
2. Longitudinal section of hardened travertine showing the petrified moss plants.
3. Cross-section of hardened travertine showing the minute canals left by the decay of the moss stems.
4. Recent travertine showing the mode of travertine formation on pendent moss plants.
5. Recent travertine formed by mosses and unicellular algae.
6. The type of travertine that develops on pendent plants of *Didymodon*.

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MOSSES FROM FLORIDA COLLECTED BY SEVERIN RAPP

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The last collection sent to us by Mr. Severin Rapp from the vicinity of Sanford, Florida, contains some very interesting species, including one tropical genus, new to the United States, *Jagerinopsis* Broth., and the extension northward of one tropical *Dicranella* determined by Mr. Williams as *D. subinclinata* Lorentz, heretofore known only from Cuba, Mexico and Panama to South America. This station in Florida and one of our own collections from the Isle of Pines, Cuba, are additions to its range as given in N. A. Flora. It grows "on clay banks along creeks" and may be looked for in the same habitats as its more common relative, *D. L'Herminieri* (*D. leptotrichoides R. & C.*). *D. heteromalla orthocarpa* also has been found, but is rare in *Florida*, and *Mnium cuspidatum* seems to reach its southern range in this state. Excellent specimens of such common species as the following were also collected: *Bruchia Donellii* and *B. Ravenellii*, *Trematodon longicollis*, *Leucobryum albidum* (Brid.) Lindb. (*L. sediforme*), *Syrrhopodon floridanus*, *Weisia longiseta*, *Funaria flavicans*, three Southern varieties of *Physcomitrium turbinatum*, two Ephemerums, and *Brachymenium Wrightii* (Sull.) Broth., all in excellent fruit. Several Archidiums—*A. alternifolium*, (sent as *A. Ravenellii* and *A. tenerrimum*) and *A. Donellii*—show that this genus varies in Florida as much as other northern species do in that moist warm climate.